

**PREPARATION AND QUALITY ASSESSMENT OF DIFFERENT TYPES
OF COMPOST**



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Submitted to

Agrotechnology Discipline

Khulna University

By

Examination Roll No.: MS-120808

In partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

IN

HORTICULTURE

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**KHULNA UNIVERSITY
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FINAL ORAL EXAMINATION OF THE M. S. Hort. Thesis**

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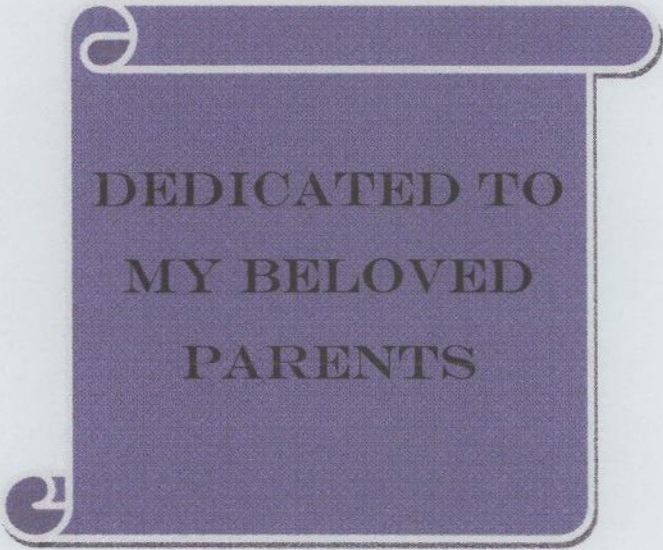
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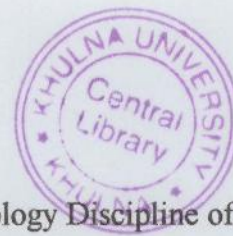
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ABSTRACT



An experiment was carried out in the Germplasm Centre of Agrotechnology Discipline of Khulna University, Khulna during the period from January to June, 2014. The experiment was conducted to assess the nutrient quality of different types of compost. Different composting materials such as water hyacinth, kitchen waste, cowdung, Farm Yard Manure (FYM) and poultry liter and the combination of those materials were used to prepare the compost. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and fifteen treatments (T_1 =100% water hyacinth, T_2 = 100% kitchen waste, T_3 = 100% cowdung, T_4 = 100% Farm Yard Manure (FYM), T_5 = 100% poultry liter, T_6 = 50% water hyacinth and 50% kitchen waste, T_7 = 50% water hyacinth and 50% cowdung, T_8 = 50% water hyacinth and 50% Farm Yard Manure (FYM), T_9 = 50% water hyacinth and 50% poultry liter, T_{10} = 50% kitchen waste and 50% cowdung, T_{11} = 50% kitchen waste and 50% Farm Yard Manure (FYM), T_{12} = 50% kitchen waste and 50% poultry liter, T_{13} = 50% cowdung and 50% Farm Yard Manure (FYM), T_{14} = 50% cowdung and 50% poultry liter and T_{15} = 50% Farm Yard Manure (FYM) and 50% poultry liter). The colors of different compost were dark brown to black and sometimes dark grey color occurs. The texture of final well decomposed compost is crumbly in which larger particles change into finer ones. Mature compost (well decomposed) has slight earthy smell. Different elements viz. total nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, zinc and boron were analyzed from these different compost materials. From the study, maximum total nitrogen (1541 ppm) and boron (542 ppm) were reported from the treatment T_{13} (50% cowdung and 50% FYM), phosphorus (8976 ppm) from T_{15} , potassium (16640 ppm) from T_9 , calcium (2858 ppm) from T_8 , magnesium (1119 ppm) from T_1 . The treatment T_{14} (50% cowdung and 50% poultry liter) contains highest amount of sulphur (6524 ppm) and zinc (318.3 ppm).

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LIST OF ABBREVIATIONS

SRDI- Soil Resources Development Institute

KU- Khulna University

PPM- Parts Per Million

DTPA- Diethylene Triamine Pentaacetic Acid

FYM- Farm Yard Manure

WH- Water Hyacinth

KW- Kitchen Waste

CD- Cowdung

PL- Poultry Liter

CHAPTER I

INTRODUCTION



The presence of organic matter in the soil is fundamental in maintaining the soil fertility and decreasing nutrient losses. Organic soil management has become the pressing need today for reversing the cycle of soil degradation and thereby putting a step forward towards soil and crop sustainability. At the same time sustainability has been farfetched even after application of organic soil inputs over a period of years (Bera *et al.*, 2013). Compost is decomposed organic matter, such as crop residues and/or animal manure. Most of these ingredients can be easily found around the farm. Compost is an organic fertilizer; it adds organic matter and nutrients to the soil (Inckel *et al.*, 2005). Composting is a decomposition process in which the substrate is progressively broken down by a succession of populations of living organisms. The breakdown products of one population serve as the substrate for the succeeding population. The succession is initiated by way of the breakdown of the complex molecules in the raw substrate to simpler forms by microbes indigenous to the substrate (Lossin, 1970). Composting helps to optimize nutrient management and the land application of compost may contribute to combat soil organic matter decline and soil erosion (Fening, 2010). Compost is solid particulate material that is the result of composting, that has been sanitized and stabilized and that confers beneficial effects when added to soil and/or used in conjunction with plants (Inckel *et al.*, 2005). Hence, an effective composting method, which enables the production of good quality compost at an economical cost, can only meet the criteria for sustainable organic soil management. The composted end-products are applied to soil to improve both its nutritional and structural characteristics: in farms, public and private gardens, recreational parks and on roadsides.

Organic waste can be recycled by composting. Thus, there is great potential for reducing the waste stream through composting (Adams and Dougan, 1981). Composting organic waste allows for decomposing the organic materials into a more compact form for management (Benson and Othman, 1993). Compost has been used at the household or small farm level for recycling of organic matter and nutrients for thousands of years. These wastes can come from many sources - crop residues, weeds, tree litter, animal manures, human wastes, suitable wastes from various industrial processes and sorted municipal wastes from towns and cities. Some of these materials can be easily incorporated directly into the soil and others will cause difficulties (FAO, 1987).

Environmental degradation is a major threat confronting the world, and the frequent use of chemical fertilizers contributes largely to the deterioration of the environment, loss of soil fertility, less agricultural productivity and soil degradation (Khan and Ishaq, 2011). Day by day the problems associated with the use of hazardous chemicals for crop protection, weed control and soil fertility are receiving increasing attention worldwide since pests, diseases and weeds become resistant to chemical pesticides and environmental pollution and ecological imbalances may occur. In the present agricultural situation there has been a growing conviction that compost is the best option available to restore and enhance soil potential in order to attain sustainable soil and crop productivity (Briggs and Courtney, 1985).

Compost improves the soil structure, the resistance of the soil against the erosive action of rain and wind, retains water and releases it slowly, so that water is available to the plants (water storage capacity) over a longer period, retains nutrients and releases them to the plants slowly over a longer period, contains the main nutrients: nitrogen (N), phosphorus (P) and potassium (K), which become available to the plants after decomposition (Inckel *et al.*, 2005). The composting process, the waste material and the composting technique must be

selected, and the parameters that affect the process (pH, temperature, moisture content, oxygen, C: N) must be controlled (Rynk and Richard, 2001).

Fertilizer is any organic or inorganic material of natural or synthetic origin that is added to a soil to supply one or more plant nutrients essential to the growth of plants. The use of manure application enhances soil productivity, increases the soil organic carbon content, soil micro-organisms, improves soil crumb structure, the nutrient status of the soil and enhances crop yield. Organic manure is also very cheap and effective as a good source of nitrogen for sustainable crop production while inorganic fertilizer is no longer within the reach of poor-resource farmers due to its high cost, has no sustainable effect on soil health, also deteriorate the environment condition and day by day increase the use of inorganic fertilizer (chemical fertilizer) for which reduce the yield with soil fertility (Tadesse *et al.*, 2013).

The major problem with the use of an organic fertilizer like compost is its low nutrient content, the slow release of such nutrients for the crops being grown, long term storage is not possible and leaching down of compost nutrients. It also requires space, time, and labor to produce considerable volume of compost. There is therefore a need to use considerable volume of compost to produce healthy crops (Louisa and Taguiling, 2013).

Based on the benefits derived from using organic compost and on the problem on organic compost as presented above, producing a compost as organic fertilizer with higher nutrient content would be quite promising not only in providing greater stability in production, but also in maintaining better soil physical and chemical properties (Rekha *et al.*, 2005).

High cost and due to scarcity of mineral fertilizer, most farmers cannot afford to use chemical fertilizer. Application of organic fertilizers (compost) has been a noble and traditional practice of maintaining soil health and fertility and when farmers use this

compost, environment do not face this chemical hazardous problem. Composting is a proven-technology that can be applied on the spot, but there are many aspects that should be improved in the technology. One of the areas for improvement is on how to improve its nutrient contents. Compost product which is known as organic fertilizer that is applied beneficially to amend the soil physical and chemical properties (Rajesh *et al.*, 2003). It suggested that the optimal degradation of compost materials can possible to increase the nutrient quality. Soil is our great resource. We have to keep it healthy for the food production of mankind and compost can help us greatly. So keeping in view, the situation with reference to organic nutrient sources, low fertility index and low productivity potential, it is directly needed that use of composts enriched with different elements be promoted.

Healthy soil produces healthy plants and creates a balance between the interconnected system of health of people, soil, soil organisms, plants, and animals. Some researchers have worked on compost by using some compost materials either individual or their combinations. But the information about the preparation of compost using different plant residue and waste and their combination and their chemical composition is meagre. So it is necessary to use different types of compost materials and their combinations for the preparation of good quality compost and analyzing this prepared compost to know their chemical composition. For this reason, the present study was undertaken to fulfil the following objectives.

- To prepare various types of compost by using different materials.
- To analyse physical properties and the nutrient contents of the prepared compost.

CHAPTER II

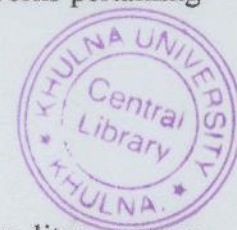
REVIEW OF LITERATURE

Composts and manures are of major importance in providing fertility in organic farming systems, since synthetic fertilizers are limited. The importance of composts as a source of humus and nutrients to increase the fertility of soil and growth of plant has been well recognized. So, proper compost preparation is very important for soil and plants.

Soil fertility deterioration is a major constraint for higher crop production in many parts of our country. The increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic fertilizer or compost have caused severe soil fertility deterioration resulting in poor harvest of crops grown. Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long-term sustainable crop productivity. Soil organic matter is a key factor for sustainable soil fertility and crop productivity. Organic matter undergoes mineralization with the release of substantial quantities of N, P, K, S and smaller amount of micronutrients. Most of the cultivated soils in our country have organic matter far way below a good agricultural soil that should contain at least 2% organic matter. Moreover, this important component of soils is declining with time due to intensive cropping and use of higher doses of nitrogenous fertilizers with little or no addition of organic fertilizer (Wolkowski, 2003).

Composting increases the beneficial effects of organic materials on soil health, soil quality, soil fertility and nutrient use efficiency. It has also been shown that some plant pests and diseases are suppressed through the application of composts and compost extracts to soils.

Many works has so far been done in home and abroad. So some of this works pertaining to the present study has been reviewed in this chapter.



2.1. Composting materials

Gaur (1997) studied on different types of compost materials like poultry liter, sewage sludge, alfalfa residues, cattle manure, food waste and farm yard manure and stated that materials are most suitable due to their high nitrogen content and also improved yields and other benefits of crops.

Dhal *et al.* (2012) experimented on the water hyacinth with saw dust as bulking agent and investigated the evolution of some physico-chemical parameters during high rate pile composting of water hyacinth in combination with cattle manure and saw dust/rice straw as a bulking agent. They suggested that the optimal degradation of water hyacinth can be possible in the presence of large amount of cattle manure.

Dincer *et al.* (2003) research on suitability of different organic substrates for composting and their composting materials are fruit and vegetable wastes, grass cuttings and waste from food processing units. They observed that materials are suitable as composting ingredients and benefited for crop growth.

Kassa *et al.* (2011) studied on the different compost materials (coffee by products, cowdung and others) and preparation of compost with them. The objectives of their study were to assess the properties of coffee by-products compost and analyzing changes in physico-chemical properties during process of composting. They proved that coffee by products compost amended with *Millettia ferruginea* and cow dung was better than other treatments for quality compost preparation and it is better to amend the coffee by-products with organic material before composting to improve the quality of the compost.

Bera *et al.* (2013) worked on physicochemical properties of raw composting materials such as green matter and cow dung where average moisture content in green matter and

cow dung varied from 70.40 to 84.65 and 76.81 to 86.62 per cent with 43.58 to 31.04 per cent organic carbon content respectively and total nutrient content ($N+P_2O_5+K_2O$) in green matter and cow dung were 2.19 and 1.95 per cent respectively.

Thakre and Fulzele (1998) concluded that the addition of green leafy biomass in the process of composting was indeed genuine as the green leafy biomass was a good source of nitrogen helping degradation of lignocellulosic waste at a faster rate.

2.2. Physical characteristics of compost

According to Darlington (2007) physical characteristics that are suggestive of mature compost include a dark brown to black color and a soil-like or musty odor. There should be little or no recognizable grass or leaves. Compost that has a sour or putrid smell is not yet matured. Based from the physical characteristics of the harvested compost, it could be said that they are almost matured except for the control treatment which was not yet matured. The absence of green biomass in the control treatment as a source of nutrient for compost organisms might have slowed down the activities of the composting organisms.

Dresboll and Thorup-Kristensen (2005) studied on the physical properties of produced compost and the process parameters of composting based on plant residues feedstock from three different species of plants (wheat, hemp, and miscanthus). They indicated that different plant feedstocks changed the texture of the compost produced noticeably, affecting parameters like water retention, particle size distribution, C/N ratio, and the amount of mineralized nitrogen.

Zmora-Nahum *et al.* (2005) experimented on the physical and chemical properties of commercial compost based on their feedstocks and location of origin and they stated that while the compost properties differed widely, there was significant correlation of properties based on the type of compost. They also found that the compost properties had more uniformity when the source of the compost was from a same area and the chemical

properties of composts were also found to correlate well with the compost type, e.g., feedstocks containing recalcitrant wastes composted slowly compared to those containing easily compostable green waste (fresh plant matter, like lawn and park trimmings, kitchen and garden waste).

2.3. Composting process

Ahmad *et al.* (2007) studied on different composting process and considered different factors that affect the composting process includes different types microorganisms that accelerate composting process. They used three types composting systems includes windrows, aerated static pile and in- vessel composting where in- vessel composting is more costly than others and windrows method is more easy and available.

Himanen and Hanninen (2011) compared different compost feedstocks, i.e., source separated kitchen waste, anaerobically and aerobically digested municipal wastewater sludge, for their composting activity and nutrient dynamics during the composting process. They showed increasing N-mineralization in the initial stages of the composting process, indicated both by the increased mineralized N content and the decreasing C/N ratio, although the trend is not so clear for the aerobic sludge compost. They also found increased nitrogen losses in form of volatile ammonia, with the aerobic sludge showing as much as 45% nitrogen loss in the initial 8 to 10 weeks. Over the long run though, the nitrogen mineralization rates varied among the feedstocks as reacted by the C/N ratios, with the biowaste compost showing a decreasing C/N ratio and the sludge-based composts showing an increasing C/N ratio.

Guo *et al.* (2012) investigated the effect of aeration rates, feedstock C/N ratios, and moisture content on a mixed feedstock of poultry manure and corn stalks. Compost stability was found to be most dependent on the aeration rates during the composting

process. The C/N ratio mainly influenced the maturity (degree of decomposition, humification, and decrease of phytotoxicity) of the compost.

Gómez *et al.* (2006) studied on the composting process by the microbial activities and found that microbial respiration forms an important parameter for determination of compost stability and microbial biomass of compost is considered as an indicator of bio-maturity.

2.4. Microbes activation on composting process

Bishop and Godfrey (1983) studied on composting process and showed that the rise in pH was induced due to the production of ammonia during ammonification and mineralization of organic nitrogen as a result of microbial activities in active composting time.

Kumar *et al.* (2011) concluded from their study that better quality compost can be prepared by enriching raw material with some sources of plant nutrients. They further reported that some microorganism can also be used to enrich the compost where phosphorus content was found maximum and it may be because of phosphorus solubilizing action of fungus.

Pereiro Neto *et al.* (1986) studied the survival of indicator organisms in sewage sludge composted with solid municipal wastes. The organisms used to monitor the effectiveness of the composting process to produce a sanitised waste were *E. coli*, faecal streptococci and *Salmonella*. They concluded that static aerated piles were more efficient than windrows in the inactivation of the indicator organisms.

Gómez *et al.* (2006) observed that microbial respiration forms an important parameter for determination of compost stability.

Seal *et al.* (2011) found that the highest content of Nitrogen (2.24 per cent) as obtained in case of compost might indicate higher fixation of atmospheric N within compost heap during composting process. Total phosphate (0.61 to 0.81 per cent) and total potash

content (0.74 to 1.19 per cent) were also higher than the minimum suggested standard (0.6 to 0.9 per cent and 0.2 to 0.5 per cent, respectively).

Blanc *et al.* (1999) stated that microbes are major drivers of the composting process, and as such, characterization and identification of microorganisms in compost is important to better understand of degradation mechanisms. Microbial community structures change during the composting process as temperature and chemical conditions change. They classified the microbial variety in composts using a combination of population counts. They reported that thermophilic bacteria were being replaced with less thermophilic bacteria as the temperature in the compost pile dropped below optimal ranges for thermophilic bacteria and their results indicated that as temperature declines and the chemical composition of the compost materials becomes more diverse, the compost is populated with a broader range of microorganisms. Microbial populations in compost depend upon feedstock and composting methods (Dees and Ghiorse, 2001).

Yeoh *et al.* (2011) observed that some factors such as temperature, moisture and microbes that affect composting are essential in evaluating the performance of an overall composting process.

2.5. Nutrient quality of compost

Khan and Ishaq (2011) experimented on different composts (Vermicompost and Pitcompost) and Garden soil (Control) in terms of their nutrient content and their effect on plant growth and results found that the vermicompost was rich in nutrients like potassium, nitrate, sodium, calcium, magnesium, and chloride and have the potential for improving plant growth than pit compost and garden soil (control).

In an attempt to improve the quality of compost from rice straw, Goyal and Sindhu (2011) used biogas slurry, consortium of fungi with *Trichoderma*, and cattle dung as compost mixture. In the prepared compost, the total nitrogen (N) content varied from 1.15% in

paddy straw alone to 2.17% in paddy straw amended with cattle dung after 90 days of decomposition. Maximum increase in total phosphorus (P) content was found with fungal culture treatment followed by inoculation of cattle dung and it varied from 0.062% in paddy straw alone to 0.164% by inoculation of fungal consortium. The total potassium (K) content also varied from 0.134 to 0.169% and maximum increase in total K was observed by inoculation of the fungal consortium. Thus, amount of N, P and K contents were found more in compost prepared with consortium of fungi and cattle dung than the compost prepared from biogas slurry.

Estevez- Schwarz *et al.* (2011) studied on different types of compost and the aim of their experiment was to promote the utilization of plants remains to produce compost that once stabilized and sanitized could be used as an organic amendments or substrate and they showed that all of the composts produced were stable, sanitized and did not contain phytotoxic substances and composts generally contained higher amount of nutrients.

In a study conducted by Znaidi (2002) to assess the quality of compost from different animal manures as organic matters, the researchers found that the pH of all treatments decreased until 7.8 to 7.4 due to the release of organic acids following the decomposition of organic substances. The lowest pH was obtained by the treatment using only cattle manure followed by animal manure mixed with wheat straw. The researchers also stressed that the presence of a carbon source such as wheat straw is very important to ensure a good composting process.

Carpenter *et al.* (2000) concluded on Biodynamic agriculture (BD) that is an organic farming system that relies heavily on compost as a fertilizer. For this reason they added composting materials in order to make Biodynamic compost and these additions produce higher quality compost under farm conditions. Finally they observed that Biodynamic preparations effected discernible changes in compost chemical and microbial parameters.

In an attempt to improve the quality of dairy manure compost, Gerngross *et al.* (2006) used organic amendments such as woodchips, sawdust and peanut hulls applied at 10% and 30% rates. The researchers found that adding 10% and 30% of three high carbon materials resulted in significantly higher organic matter of compost products from dairy manures. The study indicated that adding and increasing the rate or amount of amendments improves the quality of compost product. The study also showed that adding of the organic amendments had no consistent effects on P, Ca, Na, and soluble salts across compost products.

Fening (2010) studied on improving the fertilizer quality of cattle manure by using *Chromolaena odorata*, *Stylosanthes guyanensis* and corn stover mixture as source of nutrients at 1:1 and 2:1 plant mixture and cattle manure ratio. Results showed that composting cattle manure mixed with plant materials improved the nutrient value of cattle manure and therefore its fertilizer value. The nitrogen concentration was increased by 53 and 102% respectively for 2:1 and 1:1 which suggests that composting materials are potentially good organic amendments for improving the fertilizer value of cattle manure. The results further showed that 1:1 compost had the highest N, P, K concentration.

In the study of Abdelhamid (2004) on composting rice straw, he found total organic carbon concentration decline for mixture during composting. The decrease of volatile solids (VS) may be due to the loss of organic matter through microbial degradation. Compost N concentration increased with increasing volume of oil seed cake and poultry manure. The increase in total nitrogen may have been due to the net loss of dry mass as the loss of organic Carbon as CO₂ during composting process. More over total N can be increased by the activities of nitrogen-fixing bacteria at the end of the composting process.

Imam and Sharanappa (2002) reported that, composting of poultry manure with different crop residues (wheat and ragi straw) at varying ratios like 0.25:1, 0.5:1, 1.75:1 and 1:1 ratio for 3 months under vat method recorded high nutrient content in 1:1 proportion with the values of 3.5 % N, 4.94% P and 2.1 % K and C:N ratio of 6:1.

Ahmad *et al.* (2007) concluded that organic waste materials can be converted into value-added organic fertilizer by the addition of lower doses of nitrogen as well as biologically active substances. It is possible to get higher yield levels with complimentary use of organic and inorganic (chemical) fertilizers than the application of organic or chemical fertilizers alone. The improvement in soil health and reduction in piling of organic wastes could be extra benefit.

Bera *et al.* (2013) studied on comparative evaluation of different available and practiced composting methods viz. Vermi, Indigenous, Biodynamic and Novcom composting in terms of their end product or compost quality as well as respective cost at Maud tea estate (Maud T.E.) in Assam, India under FAO-CFC-TBI Project, 2008-2011 and observed that total nitrogen, phosphate and potash content in the compost samples were highest under Novcom composting method compared to other method and also compost indicating that all the compost samples were mature and suitable for soil application.

In a study of Louisa and Taguiling (2013), experimented on compost materials (crop residue and green biomass combinations) where available crop residue were used as the main compost material, while succulent stems plus green leaves of Ipil-ipil (*Leucaena leucocephala*) and wild sunflower (*Tithonia diversifolia*) were used as the green biomass material and treatments were crop residue and green biomass combinations at 3:0, 3:1, 3:2 and 3:3 ratios. Then their results indicated that, gradual enrichment of crop residue compost with green biomass especially those prepared at 3:3 and 3:2 crop residue-green biomass combinations gave significant increase in the nitrogen, phosphorous and

potassium contents of the compost. It also showed significant improvement on the percent organic matter, pH level, and weight of the compost product. The results further revealed that the use of green biomass-enriched crop residue compost significantly stimulated plant growth in terms of plant height, number of leaves, size of leaves, number of buds, and total weight of fresh plant biomass. Finally the overall findings of the study expressed that gradual application of green biomass during composting of crop residue produced better quality of compost that can be used to stimulate plant growth.

Stratton *et al.* (1995) experimented on the physical and chemical properties of the compost materials where important physical properties include particle size and moisture content while chemical characteristics include nutrient quality and quality of organic residues. They observed that composting two or more materials together may accelerate the composting process and moisture content and particle size of the materials producing good quality compost materials.

Hussain *et al.* (2015) studied on chemical compositions of diverse composts such as enriched composts, vermicompost and conventional compost at the completion of decomposition processes. They showed that there was no significant variation in moisture percent of different types of composts and water soluble carbon value was almost double in conventional compost than those of chemically enriched composts and vermicompost.

Rajesh *et al.* (2003) opined that micronutrient content (Mn, Zn, Fe, and Cu) was higher in enriched compost as compared to conventional compost.

Gabrielle *et al.* (2005) used a deterministic soil crop model to simulate C:N dynamics in an arable field and amended with three types of composts and a reference amendment (farmyard manure). The stability was measured using a biochemical index (a fractionation technique, cellulose, carbohydrate and lignin determination). A field trial was set up in 1998 in the Paris area, and managed as a maize and wheat rotation. After 4 years, the

composts had on average, mineralised 3-8% of their initial organic N content. This was dependent on the stability of the compost. According to the authors the difference in crop recovery of compost derived N is evidenced by the issue of N application timing. It could be expected that a fresher compost would mostly mineralise (release) during the period between the application in autumn and the planting in spring.

De Neve *et al.* (2004) have studied the possibilities of manipulating N mineralisation from high N vegetable crop residues by the addition of organic materials, with the aim of initially immobilising the mineralised residual N with a view to stimulating remineralisation at a later stage.

Bolea *et al.* (2010) studied the distribution of a large group of ions between different fractions of organic matter extracted from compost. They found that the partition of ions into a specific fraction of the dissolved (or particulate) organic matter extracted from the compost.

Reynolds *et al.* (2002) studied on soil fertility that was maintained by the use of organic fertilizers such as farmyard, manure, compost, green manure, straw and organic wastes and found that low soil organic matter content on arable lands has made them become less fertile. They also found that over use of inorganic fertilizers and intensive fieldcrop production can cause the quality of agricultural soils to decline and reduced soil physical quality and also declined crop performance and/or profitability, as well as negative environmental impacts related to the off-field movement of soil.

Wong *et al.* (1999) found that manure compost can be an alternative to chemical fertilizer to restore the soil nutrient balance; it increases the soil macro and micronutrient for plant growth.

Shyamala and Belagali (2012) studied on the changes of some typical physico-chemical, biological characteristics and heavy metal concentrations during the decomposition

process of compost. They observed that changes in the composition characteristics of the compost over-time, included increased electrical conductivity, bulk density, water holding capacity and total soluble solids etc, during the decomposition process, but the moisture content got reduced towards the end of composting (with final moisture content being around 29 %). They also concluded that the successive levels of composting process, pathogenic bacterial populations decreased and physico-chemical analysis of compost from the point of view moisture content, pH, chloride, organic matter, calcium, magnesium, total phosphorus, total nitrogen, C/N ratio, sodium and potassium agreed with recommended standards.

Barker (1997) research on composition and beneficial effect of different composts and opined that calcium and magnesium concentration were very higher in all the degradation stages of compost samples and have no hazardous effect on human health and also aid in maintaining the structure of plant cells and soil condition. He said that the main sources of nutrients in the solid wastes are food and vegetable wastes, animal wastes, fine earth, organic wastes etc.

Karnchanawong and Tadkaew (2013) reported that higher nutrient content of the compost and the higher porosity of the soil mixture, as a result of the co-composting of the saw dust, cow dung and egg shells.

Chang *et al.* (2014) showed that the organic amendments tend to increase organic P compared with soil alone and plant growth significantly increased with compost amendments.

Smith (2009) reported that compost usually contains heavy metals based on initial raw material. Generally, these heavy metals (micronutrients) are essential for plant growth. He also found that the micronutrients present in the compost, such as Zn, Cu and Fe, are utilized by the plants during the fertilizing process and these trace elements are required

for a better plant growth in trace quantities but in large quantities can cause phytotoxicity, consequently can impose hazardous risks to human and fauna.

From the literature reviewed above, it appears that many studies have been conducted on examining the preparation of quality compost and analysis the nutrient quality of various types of compost. Compost made from green waste usually contains large amounts of nitrogen, phosphorus and other nutrients. Composting involves a wide variety of physical, chemical, and biological transformations of the compost materials.

CHAPTER III

MATERIALS AND METHODS

3.1. Study area

The experiment was conducted in the Horticulture Field Laboratory and Germplasm Centre of Agrotechnology Discipline of Khulna University (KU), Khulna. The study was carried out during the period from January to June, 2014.

3.2. Composting materials of the study and collection

The basic organic raw materials used for composting were water hyacinth, kitchen waste, cowdung, Farm Yard Manure (FYM) and poultry liter. Water hyacinth was collected from the canal of the Khulna University, kitchen waste from Gallamari Bazar near to the Khulna University and cowdung, Farm Yard Manure (FYM) and poultry liter were collected from dairy farm house and poultry farm house, respectively that are located near the Khulna University.

3.3. Pit preparation

Composts were prepared by pit method. Pit method is a compost making process in pits, which is much better to be used in moisture stress and cold areas. This is because in moisture stress areas the pit keeps the available moisture for a longer time while in the cold, the pit keeps the inside temperature high enough for the decomposition process to continue (Drechsel and Kunze, 2001).

For this experiment, pit was prepared in the soil of the Horticulture Field Laboratory and Germplasm Centre. This place was selected because of dryness with the presence of trees and convenient to composting materials transportation. Pit was prepared before filling it with the available materials and pit size was 4ft length, 2ft width and 3ft depth, respectively. All sides of a pit was dry i.e., there was not any moisture leaking into the

compost pit. So, polythene paper was placed equally in every pit for preventing nutrients leached down into the soil.

3.4. Preparation of composting materials

Collected composting materials were prepared for composting process. For this purpose kitchen waste and water hyacinth were chopped into smaller pieces for rapid decomposition.

3.5. Composting process

Based on the treatments, composting materials were piled up in different thickness and set up in the pit. The heap was shuffled after one week in order to enhance the composting process by decomposing, blending and breaking up the composting materials evenly.



Fig.1. Composting process with different materials.

To make the best possible compost, the micro-organisms must be able to work optimally.

This can be achieved if the following four factors are combined to the best advantage:

- type of organic material
- air
- moisture
- temperature

The composting process was optimal when:

- various materials of different decomposition rates were combined;

- the different materials were well mixed;
- the size of the heap was accurate for the temperature to stay constant within the heap.

Aerobic condition in composting method was maintained for proper decomposition. The heap was moistened by spraying water on the surface due to sunny weather and then stirred the compost by spade.

Sometimes polythene paper spread on the surface of the compost heap. Then compost was ready for use within three months.

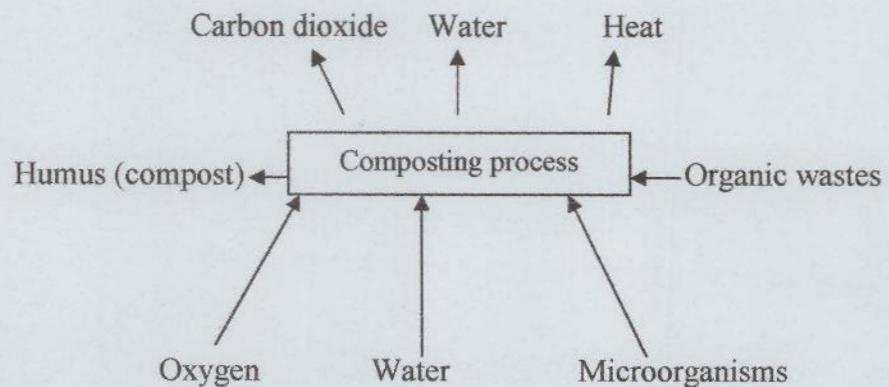


Fig.2. Inputs and outputs of the composting process (Ahmad *et al.*, 2007).

For a good composting process, 3 consecutive stages were maintained, these were as follows:

- a heating phase (fermentation),
- a cooling down phase and
- a maturation phase

3.6. Sample collection

After completion of compost preparation, sample was collected from the compost pit randomly. At first sample were collected from each pit, air drying by spreading under shade and then oven drying to get the final sample for analysis the sample.



Fig.3. Collection of sample and drying under shade.

3.7. Analysis of prepared compost

After collection of prepared compost, one gram of sample was taken from this collected sample and subjected to analyze. The samples were analyzed for physical properties (color, odour and texture) and nutrient analysis (N, P, K, S, Mg, Zn, B, and Ca) according to the standard procedure. Total N, P, K, S, Mg, Zn, B, and Ca content in compost was determined by different standard methods. For this reason one gram of final sample was digested with acid digestion method.

3.8. Digestion of compost

For analysis of compost, it was digested with diacid mixture solution. Diacid mixture is a mixture of HNO_3 and HClO_4 in a ratio of 2: 1. This diacid mixture was used for P, K, S, Mg, Zn, B, and Ca digestion but for N digestion, diacid composition consists of mixture of H_2SO_4 and HClO_4 in 2:1.

3.8. Process of digestion of compost

- At first one gram finely ground dry sample in 250ml conical flask was taken.
- Then about 20 ml diacid mixture (HNO_3 : HClO_4 in 2: 1) was added.

- The flask was stirred to moisten the sample and then heated the contents with flask at 180- 200°C.
- Heating was continued until the white fume evolved and then removed it from the hot plate and allowed to cool.
- Then 20- 30ml distilled water was added and shake well.
- Finally filtration in 100 ml volumetric flask and make the volume up to the mark with distilled water (H₂O).

Same process was followed for N digestion with H₂SO₄ and HClO₄ maintaining a ratio of 2:1. Digestion process was done in the Agricultural Chemistry Laboratory of Agrotechnology Discipline of Khulna University. Therefore, these digested samples extract were sent to the SRDI (Soil Resources and Development Institute) at Daulatpur, Khulna for nutrient analysis. Then analysis of final sample after digestion process:

- Total nitrogen was measured by Kjeldahl digestion (Kjeldahl, 1983),
- potassium (K) was determined by atomic absorption (Huang and Schulte, 1985),
- phosphorus (P) was determined Olsen method,
- calcium and magnesium were measured by Ammonium Acetate method,
- sulphur was determined by Calcium Dihydrogen Phosphate extraction method,
- zinc was measured by DTPA (Diethylene Triamine Pentaacetic Acid) extraction method and
- boron was determined by calcium chloride extraction method (Jackson, 1958).

3.9. Treatments and experimental design

For this experiment fifteen treatments was taken that was replicated three times.

The treatments were-

T₁=100% water hyacinth (WH)

T₂= 100% kitchen waste (KW)

T₃= 100% cowdung (CD)

T₄= 100% Farm Yard Manure (FYM)

T₅= 100% poultry liter (PL)

T₆= 50% water hyacinth (WH) and 50% kitchen waste (KW)

T₇= 50% water hyacinth (WH) and 50% cowdung (CD)

T₈= 50% water hyacinth (WH) and 50% Farm Yard Manure (FYM)

T₉= 50% water hyacinth (WH) and 50% poultry liter (PL)

T₁₀= 50% kitchen waste (KW) and 50% cowdung (CD)

T₁₁= 50% kitchen waste (KW) and 50% Farm Yard Manure (FYM)

T₁₂= 50% kitchen waste and 50% poultry liter (PL)

T₁₃= 50% cowdung (CD) and 50% Farm Yard Manure (FYM)

T₁₄= 50% cowdung (CD) and 50% poultry liter (PL)

T₁₅= 50% Farm Yard Manure (FYM) and 50% poultry liter (PL)

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

3.10. Data analysis

Calculated data on various parameters under study were statistically analyzed using analysis of variance (ANOVA) by MSTAT-C computer package program. Means for all the treatments were calculated and analyses of variance for all the nutrient elements under consideration were performed by F test. Means were compared for difference by Duncan's New Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results on the preparation and analysis of different types of compost have been presented in this chapter.

4.1. Analysis of physical characteristics of compost

The physical characteristics (color, texture, odour etc.) of the different types of compost (100 % water hyacinth, 100% poultry liter, 100% cowdung, 100% Farm Yard Manure, 100% kitchen waste, 50% water hyacinth and 50% kitchen waste, 50% kitchen waste and 50% FYM, 50% water hyacinth and 50% FYM, 50% water hyacinth and 50% poultry liter, 50% kitchen waste and 50% cowdung, 50% water hyacinth and 50% cowdung) have been discussed below:

4.1.1. Color

The colors of the composts vary from brown to black (Table 1) and brown being prominent. Among the 15 treatments, ten of them showed brown color in one or another way. Treatments T₃ (100% CD), T₇ (50% WH+ 50% CD) and T₁₂ (50% KW+ 50% PL) showed pure brown color; T₄ (100% FYM), T₁₃ (50% CD+ 50% FYM), T₁₄ (50% CD+ 50% PL) and T₁₅ (50% FYM+ 50% PL) had blackish brown color; T₅ (100% PL) and T₉ (50% WH+ 50% PL) gave deep brown whereas T₈ (50% WH+ 50% FYM) produced greyish brown compost. Treatments T₁₀ (50% KW+ 50% CD) and T₁₁ (50% KW+ 50% FYM) produced blackish grey compost, T₂ (100% KW) and T₆ (50% WH+ 50% KW) deep grey and T₁ (100% WH) produced grey compost.

Physical characteristics that are suggestive of mature compost include a dark brown to black color where little or no recognizable grass or leaves were used as composting materials (Darlington, 2007).

Table 1. Color and texture of different types of compost

Treatments	Treatment Description	Color	Texture
T ₁	100% water hyacinth (WH)	Grey	Larger
T ₂	100% kitchen waste (KW)	Deep grey	Larger
T ₃	100% cowdung (CD)	Brown	Small
T ₄	100% Farm Yard Manure (FYM)	Blackish brown	Finer
T ₅	100% poultry liter (PL)	Deep brown	Finer
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	Deep grey	Larger
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	Brown	Large
T ₈	50% water hyacinth (WH) and 50% (FYM)	Greyish brown	Large
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	Deep brown	Large
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	Blackish grey	Large
T ₁₁	50% kitchen waste (KW) and 50% FYM	Blackish grey	Large
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	Brown	Large
T ₁₃	50% cowdung (CD) and 50% FYM	Blackish brown	Finer
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	Blackish brown	Finer
T ₁₅	50% FYM and 50% poultry liter (PL)	Blackish brown	Finer

4.1.2. Texture

In the present study, the texture of final prepared compost was crumbly in which larger particles changed into finer ones (Table 1). But some well decomposed compost such as 100% water hyacinth (T_1) and 100% kitchen waste (T_2) contained larger particles than other treatments and the larger particles cracked manually for further analysis.

Based from the physical characteristics of the harvested compost, different compost changed the texture noticeably (Dresboll and Thorup-Kristensen, 2005).

4.1.3. Odour

The smell of well decomposed compost was not so prominent and specific. But mature compost (well decomposed) had slight earthy smell. At last of composting process, different types of compost had bitter and earthy odour.

4.2. Nutrient analysis of different compost

Different types of nutrients (total nitrogen, total phosphorus, total potassium, total calcium, total magnesium, total sulphur, total zinc and total boron) of different types of compost have been discussed here.

4.2.1. Nitrogen

Analysis showed that there was a significant difference on the content of total nitrogen among the treatments (Appendix I). Total nitrogen (N) consists of all forms of nitrogen such as organic N, ammonium N ($\text{NH}_4^+\text{-N}$), and nitrate N ($\text{NO}_3^-\text{-N}$). The total nitrogen values ranged from 74.66 ppm to 1541.0 ppm among 15 treatments (Table 2). Total nitrogen varied significantly among the treatments and the maximum amount of nitrogen (1541.0 ppm) was found from T_{13} that was 50% CD and 50% FYM compost which was statistically similar with the T_9 (1540.0 ppm) and T_8 (1402.0 ppm) followed by T_3 (1193

ppm) and T₁₁ (1188.0 ppm). The minimum amount of total nitrogen (74.66 ppm) was obtained from T₁₅ (50% FYM+ 50% PL) which was statistically similar with the T₁₄ (50% CD + 50% PL). No significant difference however, was observed between T₅ (100% PL) and T₇ (50% WH+ 50% CD) treatments.

Highest total Nitrogen (5100.0 ppm) was observed from combination of crop residue and green biomass compared to the only crop residue (Louisa and Taguiling, 2013).

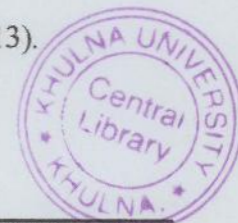


Table 2. Total nitrogen content of different types of compost

Treatments	Treatment Description	Nitrogen (ppm)
T ₁	100% water hyacinth (WH)	1230.0b
T ₂	100% kitchen waste (KW)	771.0cd
T ₃	100% cowdung (CD)	1193.0b
T ₄	100% Farm Yard Manure (FYM)	825.0cd
T ₅	100% poultry liter (PL)	563.7d
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	980.3bc
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	563.7d
T ₈	50% water hyacinth (WH) and 50% (FYM)	1402.0ab
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	1540.0a
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	841.7cd
T ₁₁	50% kitchen waste (KW) and 50% FYM	1188.0 b
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	560.0d
T ₁₃	50% cowdung (CD) and 50% FYM	1541.0a
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	143.3ef
T ₁₅	50% FYM and 50% poultry liter (PL)	74.7f
Level of Significance		**
CV (%)		13.88

**=Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

In this study, we found highest nitrogen from 50% CD and 50% FYM which suggested that combinations can produce more nitrogen than individual treatment.

The total soil nitrogen content after rice harvest increased significantly in response to the application of FYM (Tadesse *et al.*, 2013).

The high temperature and excessive amount of ammonia inhibited the activity and the growth of nitrifying bacteria in the thermophilic phase (Morisaki *et al.*, 1989). This seems to suggest that organic nitrogen mineralization is the limiting step in nitrification since such mineralization was extremely low during the last phase of composting, when the supply of ammonium available to the nitrifying bacteria would have been reduced (Sanchez-Monedero *et al.*, 2001).

Composting materials such as cowdung mixed with plant materials improved the nutrient quality of compost and therefore its fertilizer value. The nitrogen concentration was increased by 5300 and 10200 respectively which suggests that composting materials are potentially good organic amendments for improving the fertilizer value of compost (Fening, 2010).

4.2.2. Phosphorus

The water solubility of phosphorous decreased with the humification thereby showing that phosphorous solubilized during the decomposition was subjected to further immobilization by the compost accelerator microorganisms (Elango *et al.*, 2009). The total phosphorus consists of HPO_4^{2-} and H_2PO_4^- .

There was significant variance among the treatments in respect of phosphorus content (Appendix I). The total phosphorus content ranged from 2184.0 ppm to 8974.0 ppm in different compost types. The highest value of total phosphorus (8974.0 ppm) was found from T₁₅ (50% FYM+ 50% PL) which was statistically similar with the T₂ (8207.0 ppm),

T₉ (8455 ppm) and T₁₄ (8276 ppm) and the lowest value of total phosphorus (2184.0 ppm) was found from T₁ (100% WH) (Table 3).

The highest (4782.0 ppm) amount of phosphorus was reached in the compost containing organic waste and the lowest (1674.0 ppm) in the compost that did not contain organic waste. This was because the organic waste generated rich in phosphorus content and obviously contributes to enriching the compost (Estevez- Schwarz *et al.*, 2011).

Table 3. Phosphorus content of the different compost

Treatments	Treatment Description	Phosphorus (ppm)
T ₁	100% water hyacinth (WH)	2184.0d
T ₂	100% kitchen waste (KW)	8207.0a
T ₃	100% cowdung (CD)	4739.0c
T ₄	100% Farm Yard Manure (FYM)	5256.0bc
T ₅	100% poultry liter (PL)	7651.0ab
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	2580.0d
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	5581.0bc
T ₈	50% water hyacinth (WH) and 50% (FYM)	2568.0d
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	8455.0a
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	6602.0b
T ₁₁	50% kitchen waste (KW) and 50% FYM	5477.0bc
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	6172.0b
T ₁₃	50% cowdung (CD) and 50% FYM	3487.0cd
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	8276.0a
T ₁₅	50% FYM and 50% poultry liter (PL)	8974.0a
Level of Significance		**
CV (%)		16.14

**=Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

The result indicated that the FYM, poultry liter, cowdung and kitchen waste and their combination performed better result during composting process and gave maximum amount of phosphorus due to they are enough in phosphorus concentrations. The increase in phosphorus after FYM and cowdung application might be due to the direct addition phosphorus through decomposition of the FYM and cowdung added to the soil (Tadesse *et al.*, 2013).

Maximum increase in total phosphorus (P) content was found in FYM with fungal culture treatment and it varied from 620.0 ppm in paddy straw alone to 1640.0 ppm in other materials by fungal inoculation (Goyal and Sindhu, 2011).

4.2.3. Potassium

The total potassium (K^+) content of the finished compost has shown in Table 4. In the present study, potassium concentration varied from 2863.0 ppm to 16640.0 ppm. There was significant variation among the treatments in respect of potassium (Appendix I).

The highest total potassium (16640.0 ppm) was obtained from T₉ (50% water hyacinth+ 50% poultry liter) which was followed by the T₂, T₁₂ and T₁₄ treatments with potassium content of 11730.0 ppm, 10730.0 ppm and 10730.0 ppm, respectively whereas the lowest amount of total potassium (2863.0 ppm) was obtained from T₄ (100% FYM) which was statistically similar with T₃ (100% CD) and T₁₁ (50% KW+ 50% FYM).

Goyal and Sindhu (2011) reported to have range of total potassium content from 13400.0 ppm to 16900.0 ppm in composts made from rice straw with different molecule.

From the Table 4, it is observed that the water hyacinth, poultry liter, kitchen waste and cowdung and their combination gave higher amount of potassium. This result occurred due to the various compost and their combinations were rich in potassium concentration.

Table 4. Potassium content of the different types of compost

Treatments	Treatment Description	Potassium (ppm)
T ₁	100% water hyacinth (WH)	7733.0cd
T ₂	100% kitchen waste (KW)	11730.0b
T ₃	100% cowdung (CD)	2928.0f
T ₄	100% Farm Yard Manure (FYM)	2863.0f
T ₅	100% poultry liter (PL)	9763.0bc
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	6052.0de
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	6853.0d
T ₈	50% water hyacinth (WH) and 50% (FYM)	5861.0de
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	16640.0a
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	5852.0de
T ₁₁	50% kitchen waste (KW) and 50% FYM	2925.0f
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	10730.0b
T ₁₃	50% cowdung (CD) and 50% FYM	3903.0ef
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	10730.0b
T ₁₅	50% FYM and 50% poultry liter (PL)	7750.0cd
Level of Significance		**
CV (%)		12.96

**=Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Potassium is highly soluble in the wastes. Therefore, potassium is leached easily. The insoluble potassium salts can be solubilized by the decomposition of the wastes. Potassium increases during the period of composting (Gallardo-Lara and Nogales, 1987).

4.2.4. Calcium

Calcium is one of the most important nutrient required by the organisms and can also aid in maintaining the structure of plant cells and soil condition. Calcium has no hazardous effect on human health.

Calcium (Ca^{+}) concentration was very higher in all the degradation stages of compost samples. Calcium concentrations of compost samples varied from 79.87 ppm to 2858.0 ppm. Analysis showed that there was a significant difference on the content of total nitrogen among the treatments (Appendix I).

Table 5. Amount of calcium concentration of different compost

Treatments	Treatment Description	Calcium (ppm)
T ₁	100% water hyacinth (WH)	2453.0bc
T ₂	100% kitchen waste (KW)	1717.0fg
T ₃	100% cowdung (CD)	1200.0h
T ₄	100% Farm Yard Manure (FYM)	1663.0fg
T ₅	100% poultry liter (PL)	2300.0cd
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	2420.0bc
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	2299.0cd
T ₈	50% water hyacinth (WH) and 50% (FYM)	2858.0a
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	1865.0ef
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	1418.0gh
T ₁₁	50% kitchen waste (KW) and 50% FYM	1603.0fg
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	2741.0ab
T ₁₃	50% cowdung (CD) and 50% FYM	2060.0de
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	2365.0cd
T ₁₅	50% FYM and 50% poultry liter (PL)	79.87i
Level of Significance		**
CV (%)		6.73

The highest (2858.0 ppm) was found from T₈ (50% WH and 50% FYM) and the lowest calcium concentration (79.87 ppm) was observed from T₁₅ (50% FYM and 50% PL).

The T₁₂ (2741.0 ppm) treatment was also significantly higher than the other treatments and the T₁ (100% WH) and T₆ (50% WH and 50% KW) treatments were not significantly

different from each other while T_2 (1717.0 ppm), T_4 (1663.0 ppm) and T_{11} (1603.0 ppm) were statistically similar (Table 5).

The highest concentration of calcium was observed in the compost containing ash (which depend on the nature of burning materials and combustion condition) and organic materials due to different burning materials has higher amount of calcium concentration (Tadesse *et al.*, 2013).

4.2.5. Magnesium

Magnesium (Mg) was significantly increased during composting process. Under this study, magnesium concentrations among the various types of compost are shown in Table 6. Magnesium content was varied significantly among the treatments (Appendix I). Magnesium concentrations varied from 43.46 ppm to 1119.0 ppm. Magnesium concentration was very higher in all the degradation stages of compost samples. The maximum (1119 ppm) from T_1 (100% WH) which was statistically similar with the T_8 (1117 ppm) followed by T_{11} (1022 ppm) and the minimum concentration of magnesium (43.46 ppm) among the compost was observed for T_{15} (50% FYM and 50% PL).

Magnesium concentrations varied from 9960.0 to 11510.0 ppm in comparison with recommended standards in which magnesium concentration was very higher in all the degradation stages of compost samples (Barker, 1997).

The highest concentrations of magnesium observed from water hyacinth alone and also combination of water hyacinth and Farm Yard Manure due to this compost are rich in magnesium concentration.



Table 6. Magnesium concentrations of the various composts

Treatments	Treatment Description	Magnesium (ppm)
T ₁	100% water hyacinth (WH)	1119.0a
T ₂	100% kitchen waste (KW)	693.0c
T ₃	100% cowdung (CD)	705.0cd
T ₄	100% Farm Yard Manure (FYM)	778.5c
T ₅	100% poultry liter (PL)	936.1b
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	935.9b
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	972.0b
T ₈	50% water hyacinth (WH) and 50% (FYM)	1168.0a
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	741.6cd
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	510.6de
T ₁₁	50% kitchen waste (KW) and 50% FYM	1022.0ab
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	707.8cd
T ₁₃	50% cowdung (CD) and 50% FYM	839.3bc
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	694.1d
T ₁₅	50% FYM and 50% poultry liter (PL)	43.46gh
Level of Significance		**
CV (%)		8.86

**=Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.6. Sulphur

The present investigation on sulphur varied from 181.5 ppm to 6524.0 ppm. There was significant difference among the treatments for sulphur concentration (Appendix I). The variation of sulphur concentrations mainly depends on the decomposition of final compost. The highest amount of sulphur (6524.0 ppm) was obtained from T₁₄ (50% CD+ 50% PL) which was statistically similar with the T₁₀ (5947.0 ppm) and the lowest amount of sulphur (181.5 ppm) was observed from T₁₅ (50% FYM+ 50% PL) and (Table 7).

Table 7. Sulphur concentrations of different types of compost

Treatments	Treatment Description	Sulphur (ppm)
T ₁	100% water hyacinth (WH)	1573.0de
T ₂	100% kitchen waste (KW)	2055.0d
T ₃	100% cowdung (CD)	818.3ef
T ₄	100% Farm Yard Manure (FYM)	4368.0b
T ₅	100% poultry liter (PL)	1267.0e
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	1558.0de
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	880.0ef
T ₈	50% water hyacinth (WH) and 50% (FYM)	2040.0d
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	4467.0b
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	5947.0a
T ₁₁	50% kitchen waste (KW) and 50% FYM	4543.0b
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	2265.0d
T ₁₃	50% cowdung (CD) and 50% FYM	3227.0c
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	6524.0a
T ₁₅	50% FYM and 50% poultry liter (PL)	181.5f
Level of Significance		**
CV (%)		10.35

**=Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

The maximum amount (4200.0 ppm) of sulphur was made from cotton waste due to proper degradation where amount (2200.0 ppm) from its initial stage (Mondini *et al.*, 2003). So proper degradation of different compost such as FYM, cowdung and poultry liter increased the sulphur amount in the compost.

4.2.7. Zinc

The concentration of zinc ranged from 10.04 ppm to 318.3 ppm. There was a significant difference on the content of zinc among the treatments (Appendix I). The maximum (318.3 ppm) was found from T₁₄ (50% CD and 50% PL) followed by T₁ (312.7 ppm) and the minimum value of zinc concentration (10.04 ppm) was obtained from T₁₅ (50% FYM and 50% PL).

Table 8. Amount of zinc concentration of the different compost

Treatments	Treatment Description	Zinc (ppm)
T ₁	100% water hyacinth (WH)	312.7ab
T ₂	100% kitchen waste (KW)	103.3ef
T ₃	100% cowdung (CD)	101.7ef
T ₄	100% Farm Yard Manure (FYM)	192.7d
T ₅	100% poultry liter (PL)	96.67ef
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	94.33ef
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	80.33f
T ₈	50% water hyacinth (WH) and 50% (FYM)	239.0c
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	123.3ef
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	125.7e
T ₁₁	50% kitchen waste (KW) and 50% FYM	275.7bc
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	124.3ef
T ₁₃	50% cowdung (CD) and 50% FYM	272.3bc
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	318.3a
T ₁₅	50% FYM and 50% poultry liter (PL)	10.04g
Level of		**
Significance		
CV (%)		10.31

**=Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Zinc is one of the most important micronutrient required by the organisms. In present study, zinc concentration among different compost types shown in Table 8.

4.2.8. Boron

The boron concentration in all compost samples varied from 17.40 ppm to 542.0 ppm (Table 9). The boron concentration for all the stages of compost samples had increased.

Boron is an important micronutrient element for plants and it is of particular concern in plants, since its accumulation in soil is due to application of soil amendment such as compost.

Table 9. Boron concentration of the various composts

Treatments	Treatment Description	Boron (ppm)
T ₁	100% water hyacinth (WH)	390.1bc
T ₂	100% kitchen waste (KW)	414.8bc
T ₃	100% cowdung (CD)	381.2c
T ₄	100% Farm Yard Manure (FYM)	462.5b
T ₅	100% poultry liter (PL)	223.5e
T ₆	50% water hyacinth (WH) and 50% kitchen waste (KW)	305.2d
T ₇	50% water hyacinth (WH) and 50% cowdung (CD)	190.3e
T ₈	50% water hyacinth (WH) and 50% (FYM)	396.3bc
T ₉	50% water hyacinth (WH) and 50% poultry liter (PL)	413.5bc
T ₁₀	50% kitchen waste (KW) and 50% cowdung (CD)	535.0a
T ₁₁	50% kitchen waste (KW) and 50% FYM	396.0bc
T ₁₂	50% kitchen waste (KW) and 50% poultry liter (PL)	450.7bc
T ₁₃	50% cowdung (CD) and 50% FYM	542.0a
T ₁₄	50% cowdung (CD) and 50% poultry liter (PL)	456.0bc
T ₁₅	50% FYM and 50% poultry liter (PL)	17.40f
Level of Significance		**
CV (%)		7.93

Concentration of boron significantly varied among the treatments (Appendix I). The maximum (542.0 ppm) was observed from T₁₃ (50% CD and 50% FYM) which was statistically similar with T₁₀ (535.0 ppm). The minimum concentration of boron (17.40 ppm) was observed for T₁₅ (50% FYM and 50% PL). There is no significant difference among the T₂ (100% KW), T₈ (50% WH and 50% FYM), T₉ (50% WH and 50% PL), T₁₁ (50% KW and 50% FYM), T₁₂ (50% KW and 50% PL) and T₁₄ (50% CD and 50% PL) where their values were 414.8 ppm, 396.3 ppm, 413.5 ppm, 396.0 ppm, 450.7 ppm and 456.0 ppm, respectively.

The concentration of boron can vary considerably among animal manures (Bolan *et al.*, 2004). Animal manure (cowdung, FYM and poultry liter) and organic waste (kitchen waste) produced higher amount of boron.



CHAPTER V

SUMMARY AND CONCLUSION

Organic farming and organic products are gaining momentum in the agricultural sector. Quality control during compost production should ensure adequate chemical and physical properties as well as an adequate degree of stability and maturity. So an experimental study was carried out successively to prepare and analyse of different types of compost.

Summary

For producing sound and good quality compost, chemical and physical properties of the compost should be determined by the end of processing period; therefore, the main objective of this research was to study the chemical and physical properties of compost with different materials (water hyacinth, kitchen waste, poultry liter, cowdung and FYM). The experiment was conducted in the Germplasm centre in Khulna University campus. In this study, composts were prepared by pit method and various materials were used for compost preparation. The present experiment received 15 treatments with three replications.

The physical properties (color, texture, odour) of the various types of compost (100% water hyacinth (WH), 100% kitchen waste, 100% cowdung (CD), 100% Farm Yard Manure (FYM), 100% poultry liter (PL), 50% water hyacinth (WH) and 50% kitchen waste (KW), 50% water hyacinth (WH) and 50% cowdung (CD), 50% water hyacinth (WH) and 50% Farm Yard Manure (FYM), 50% water hyacinth (WH) and 50% poultry liter (PL), 50% kitchen waste (KW) and 50% cowdung (CD), 50% kitchen waste (KW) and 50% Farm Yard Manure (FYM), 50% kitchen waste (KW) and 50% poultry liter (PL), 50% cowdung (CD) and 50% Farm Yard Manure (FYM), 50% cowdung (CD) and 50% poultry liter (PL) and 50% Farm Yard Manure (FYM) and 50% poultry liter (PL)) were analyzed where different results had observed. The colors of different compost were

dark brown to black and sometimes dark grey color occurs. The texture of final well decomposed compost is crumbly in which larger particles change into finer ones. Mature compost (well decomposed) has slight earthy smell. At the last of composting process, different types of compost had bitter and earthy odour. The chemical properties such as different types of nutrients (total nitrogen, total phosphorus, total potassium, total calcium, total magnesium, total sulphur, total zinc and total boron) of different compost types were analyzed through various methods.

In this study, the concentration of total nitrogen ranged from 74.66 ppm to 1541 ppm for different compost types. The result shows that the concentrations of nitrogen of different compost were significant. The lowest amount of total nitrogen (74.66 ppm) was found from T₁₅ (50% FYM+ 50% PL) and the highest (1541 ppm) was found from T₁₃ (50% CD+ 50% FYM).

The phosphorus values ranged from 2184 ppm to 8974 ppm for different compost types. The lowest phosphorus (2184 ppm) was found from T₁ (100% WH) followed by the T₆ and T₈ and the highest phosphorus (8974 ppm) was from T₁₅ (50% FYM+ 50% PL).

The potassium concentration varied from 2863 ppm to 16640 ppm where the lowest concentration was 2863 ppm for T₃ (100% cowdung) preceded by T₁₁ (50% KW and 50% FYM) and the highest value (16640 ppm) was revealed from T₉ (50% WH and 50% PL).

The concentration of calcium and magnesium varied from 79.87 ppm to 2858 ppm and 43.46 ppm to 1119 ppm respectively. The highest value of calcium and magnesium were 2858 ppm and 1119 ppm, respectively from T₈ (50% WH+ 50% FYM) and T₁ (100% WH) and the lowest value of calcium and magnesium were 79.87 ppm and 43.46 ppm respectively from T₁₅ (50% FYM+ 50% PL). In the present investigation sulphur varied from 181.5 ppm to 6524 ppm. The highest sulphur (6524 ppm) was obtained from the treatment T₁₄ (50% CD+ 50% PL).

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The important micronutrients zinc and boron were analyzed from the well decomposed compost. The lowest value of zinc and boron were 10.04 ppm and 17.40 ppm, respectively for T₁₅ (50% FYM+ 50% PL) and the highest value of zinc and boron were 318.3 ppm and 542 ppm, respectively for T₁₄ (50% CD and 50% PL) and T₁₃ (50% CD+ 50% FYM).

Conclusion

Higher final concentration of nutrients quality of compost prepared from water hyacinth, kitchen waste, cowdung, poultry liter and FYM and in various combinations.

The obtained results indicated that the total nitrogen value ranged from 74.66 ppm (T₁₅) to 1541 ppm (T₁₃), phosphorus values ranged from 2184 ppm (T₁) to 8974 ppm (T₁₅), potassium concentration varied from 2863 ppm (T₃) to 16640 ppm (T₉) for different compost types. Then the results also showed that calcium concentration varied from 2858 ppm (T₈) to 79.87 ppm (T₁₅), magnesium value varied from 43.46 ppm (T₁₅) to 1119 ppm (T₁) whereas sulphur concentration varied from 181.5 ppm (T₁₅) to 6524 ppm (T₁₄). The results observed micronutrients where zinc value ranged from 10.04 ppm (T₁₅) to 318.3 ppm (T₁₄) and boron concentration varied from 17.40 ppm (T₁₅) to 542 ppm (T₁₃).

From the study, T₉ (50% WH+ 50% PL) and T₁₄ (50% CD+ 50% PL) gave highest amount of nutrient composition and T₁₃ (50% CD and 50% FYM), T₈ (50% WH and 50% FYM) and T₁₀ (50% KW and 50% CD) also performed better. So it can be concluded that combination of compost materials showed better result.

Different types of composting materials like water hyacinth, kitchen waste, poultry liter, cowdung and Farm Yard Manure may be used as an alternative materials and method for improving the nutrient quality (N, P, K, Ca, Mg, S, Zn, B) of various types of compost. The composting material must be controlled carefully because the rapid decomposition uses up oxygen that causes further problems as the aerobic microorganisms are replaced by the anaerobic ones. In support to a healthier food and environment, composting should be practiced and promoted by everybody. Further researches in improving the quality of compost using other types of composting materials in combination with other types of residue and waste are also recommended.

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APPENDICES

Appendix I. Analysis of variance of nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, zinc and boron

Source of variance	Degree of freedom	Mean square		
		Nitrogen	Phosphorus	Potassium
Replication	2	3465.800	539499.231	2676.956
Treatment	14	504372.086**	15864872.966**	45368200.946**
Error	28	16723.586	860944.458	942182.837

Appendix I. continued....

Source of variance	Degree of freedom	Mean square		
		Magnesium	Sulphur	Calcium
Replication	2	24990.451	25720.800	28186.667
Treatment	14	98735.133**	10133188.229**	708796.571**
Error	28	5667.154	98802.371	19138.595

Appendix I. continued....

Source of variance	Degree of freedom	Mean square	
		Zinc	Boron
Replication	2	1753.356	186.311
Treatment	14	24328.403**	41498.392**
Error	28	302.570	908.402



Plate 1. Preparation of compost



Plate 2. Collection of compost



Plate 3. Drying of compost under shade



Plate 4. Digestion of compost



Plate 5. Analysis of compost



Appendix II. Some pictorial presentation of compost preparation and analysis by using different composting materials